The nature of mass masonry granite walling and the potential for retrofit internal wall insulation strategies

Gerard Buda,* Bruce Taylor and Amar Bennadji
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*Robert Gordon University, Scott Sutherland School, Garthdee Road, Aberdeen AB10 7QG, UK.
e-mail: g.buda@rgu.ac.uk

Gerard Buda

Bruce Taylor

Amar Bennadji

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***Gerard Buda** is a chartered building surveyor, senior lecturer and business development manager at Robert Gordon University. He is also on the editorial board of* Journal of Building Survey, Appraisal & Valuation.

***Bruce Taylor** is a lecturer and chartered building scientist with extensive experience of commercial building performance auditing.*

***Amar Bennadji** is a lecturer and architect and leads the international relationship with architects across six countries.*

Abstract

Traditional buildings constructed of solid granite walling that have timber framing with lath and plaster internal finish are not thermally efficient when compared with modern constructions. They are also termed 'hard-to-treat' as they need special care and attention to historic detailing, breathability and hygrothermal performance. These traditional buildings were originally constructed with lime mortar but during the period of mass Housing Disrepair Notices, many of these buildings were re-pointed using OPC-based cement/sand mortar. While the 'whole house' needs to be considered in any thermal improvement strategy, granite walling presents a particular characteristic which demands a different approach to that of sandstone or limestone walling when considering internal wall insulation. This paper explores the main issues to consider when contemplating a thermal improvement strategy from the material perspective. The buildings identified in this paper are in the North-East of Scotland.

Keywords: granite walling, hygrothermal performance, stone characteristics, breathability

INTRODUCTION

Within the last few years there has been a drive to retrofit insulation products of several types to the inside of solid mass masonry walling in order to improve the thermal performance. The drivers for this have come from UK and Scottish Government, in part via the Scottish Government body, Historic Scotland, as a result of the Kyoto Protocol and other carbon reduction drivers. There has been a definition of 'hard-to-heat' properties and 'hard-to-treat' as a result of the quantity of such residential properties, often in tenemental construction (but not exclusively) and also the drive to reduce fuel poverty.[1] In addition, the Scottish Housing Quality Standard,[2] the Green Deal and the recent Energy Efficiency Standard for Social Housing have instigated a drive to improve the existing housing stock.

It is clear and obvious that housing accounts for approximately 34 per cent of the carbon footprint of Scotland and 32 per cent in the

UK as a whole. In order to meet the ambitious Scottish Government targets, existing and older construction in general needs to be upgraded by ensuring that these properties have a reduced energy demand for both space and water heating.

Lowering energy demand and subsequent reduction of CO_2 for space heating can be achieved effectively by: draught proofing; installing more efficient heating systems; insulating appropriate roof spaces; double glazing; and more careful management of the home by its occupants. Simple solutions that are technically passive are very effective when compared with more complex solutions requiring occupant training and also behavioural change — a long slow process with dubious results when considered over a large population sample. One of the more difficult conundrums, however, has been the question of how to improve the thermal performance of the traditional stone wall finished with an internal cavity and lath and plaster.

This paper will explore the issues to be analysed before considering an Internal Wall Insulation (IWI) strategy in and around Aberdeen where the predominant traditional construction of pre-Second World War housing is solid mass masonry walling, built predominantly of granite.

CHARACTERISTICS OF GRANITE

Granite has been the material of choice for residential building in and around Aberdeen since before the Industrial Revolution but became more extensive when the quarry industry became more industrialised around the 1750s (see Figure 1). Prior to the Industrial Revolution, many houses of the landed gentry and wealthy merchants would be constructed of granite. Indeed, going back to the feudal system, the region's tower houses and castles were also constructed of solid mass masonry walling. The stone used in earlier buildings was often field rubble or stone that was easily accessible; here, the re-use of the material is evident in several notable structures because of its durability when considered alongside other natural stones, such as sandstone or limestone.

The characteristics of granite, with its durability and predominance around the Aberdeen area, make it an ideal building stone. It was the predominant building stone because it was local and plentiful, and the granite industry grew with the Industrial Revolution and a period of population expansion, with the consequential demand for housing and the relocation from a rural to an urban-based economy.

A look at the characteristics of granite in relation to other stones (as shown in Table 1), makes clear its attractiveness.

The stone is hard, much less porous than sandstone and limestone and these characteristics make it eminently durable. Dr Maureen Young of The Masonry Conservation Research Unit at Robert Gordon University declared that granite is much more durable than other common building stones and 'decay is generally superficial, involving flaking and spalling of the surface'.[4] This superficial surface decay is usually caused only by gypsum crust in unexposed and sheltered areas and does not have a significant effect on the long-term performance of the material.

When used in residential masonry structures, however, these very attractive features also make homes built from this stone less easy to upgrade thermally. The fact that the stone is dense, has low porosity and relatively poor breathability, means that the hygrothermal performance of the wall as a whole performs significantly differently to those built of sandstone and limestone. Relatively speaking, sandstone and limestone walls built in traditional lime mortar breathe through the pores in the stone as well as the lime-based mortar with which most of these walls would have been constructed. Granite walling, however, relies much more on the mortar bedding and pointing for its breathability as the stone is significantly less porous.

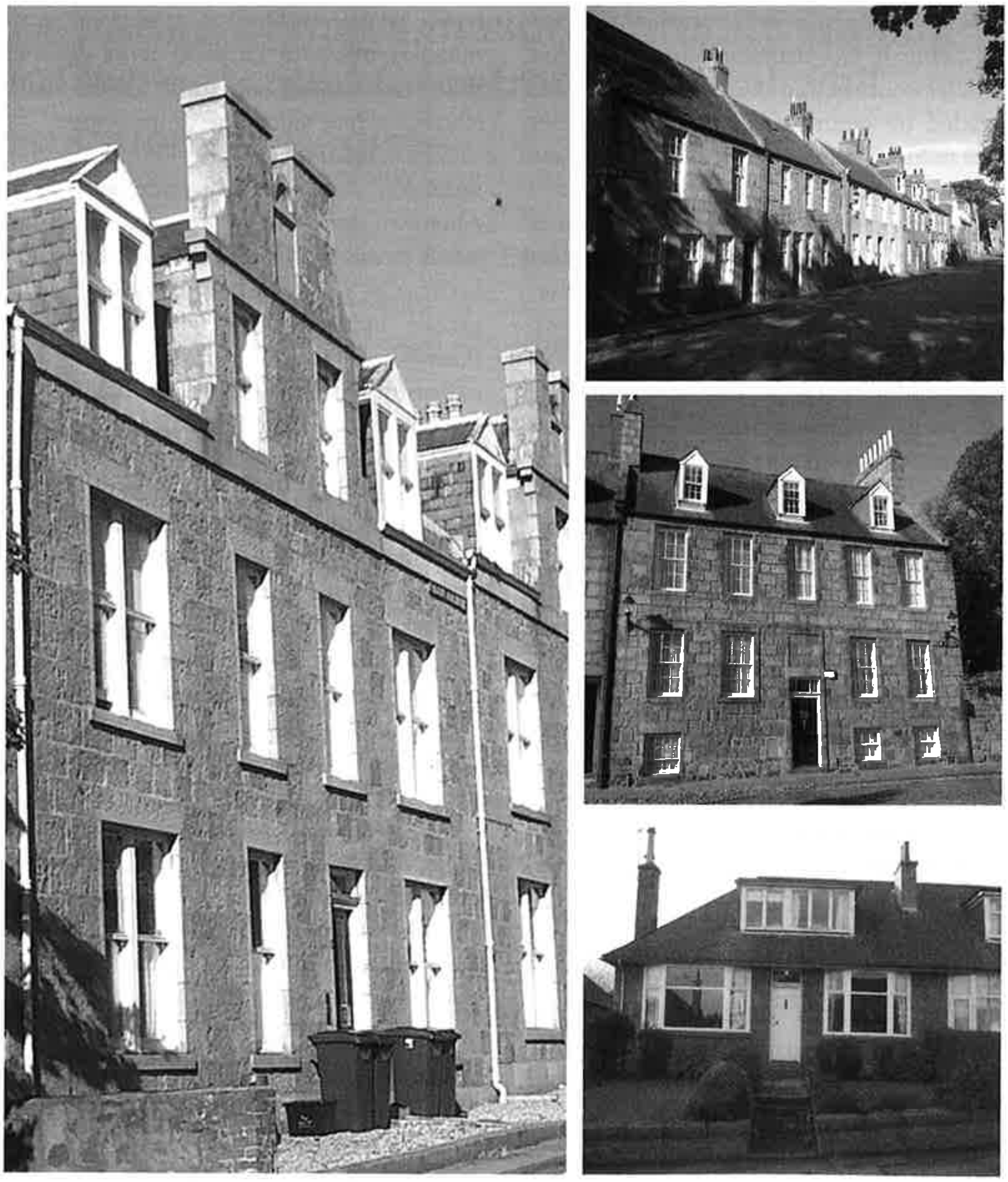

Figure 1: Examples of granite housing *circa* 1800–1937

Table 1: Typical characteristics of natural stone[3]

Stone type	*Density (kg/m³)*	*Crushing strength (N/mm²)*	*Porosity (%)*	*Thermal conductivity (W/mK)*	*Geological formation*
Granite	2560-3200	180-250	0.6–0.8	2.2-2.3	Igneous
Sandstone	2130-2750	50-125	10-20	1.2-1.7	Sedimentary
Limestone		30-165	5–30	1.2-1.4	
Whitestone	2800-3040	200-220	0.5-1.5	1.2-1.6	Igneous/ metamorphic

The variations in the build quality and external pointed area are therefore of enormous importance to the breathability of the wall structure. If these walls are well maintained and pointed in appropriate lime mortar then the best possible moisture performance is likely. However, if the walls are repointed in less pervious materials, such as Ordinary Portland Cement (OPC) mortar, then the performance will be drastically reduced. It must also be noted that there is a limit to the porosity characteristic of the mortar in the opposite direction; a too-porous mortar is likely to allow too much moisture into the wall and result in different problems.

It is also worth noting that 'The porosity of a material is a measure of the total pore space within a body. It is important to bear in mind that a high porosity does not always mean the stone has a high permeability as the pores within the stone may not be interconnected'[5] and indeed, *vice versa*.

THE WALL CONSTRUCTION

Most low rise residential granite buildings built in the Aberdeen area before the late 1930s were constructed of a boulder or stone foundation. The wall utilised much lime mortar and pinings. The external face of the granite has numerous finishes and patterns — determined by the quality of the project, the finance available, the abilities of the masons and the design of the master builder (see Figure 2).

The nature of the built wall varies significantly from section to section and, generally, the wall construction of similar periods can be quite different. The regularity of the sandstone wall, with the distinct 'twin wall' construction and the infill are each different from the typical granite wall.

The internal finish of sandstone, limestone and granite walls, however, is very similar. The internal wall is normally lined out with vertical timber straps fixed to timber dooks rammed into the lime mortar beds between the stone. Horizontal timber laths (axe split or sawn depending on building age and location) are then nailed to the vertical straps before the application of two coats of plaster with hair 'reinforcement'. However, here too, there is a significant difference when compared with sandstone construction; the left-hand sketch is taken from Historic Scotland, Technical Paper 10,[6] while the adjoining photographs are from the author's portfolio.

In granite walling the timber straps are invariably and deliberately spaced out from the inner face of the stone and do not normally make contact with the wall, although the timber dooks, to which the straps are nailed, do. The 'cavity' which consequently exists is of variable thickness but isolates the inner finishes from the stone wall. This cavity is generally well ventilated and the flow of air can be readily detected, but its depth can vary from about 40mm to about 75mm. This construction and the use of insulation in the cavity has been the 'eureka' moment for the carbon reduction proponents and those wishing to improve the thermal performance of their home. This is the subject of the second paper in this short series.

While the sandstone wall performs relatively consistently across the entire mass, granite does not. The pathways of moisture movement during wetting and drying cycles are predominant within the lime mortar bedding with relatively small changes within the stone itself. While granite is not impervious, it does have varying degrees of porosity (low) depending on its natural state. In addition, if the building has been repointed with OPC-based cement/sand mortar then the ability of the wall to breathe will be significantly compromised and therefore remedial action would be necessary before an insulation strategy was decided upon.

Hydraulic limes display an additional mechanical strength due to their hydraulic set. When compared to fat limes, they

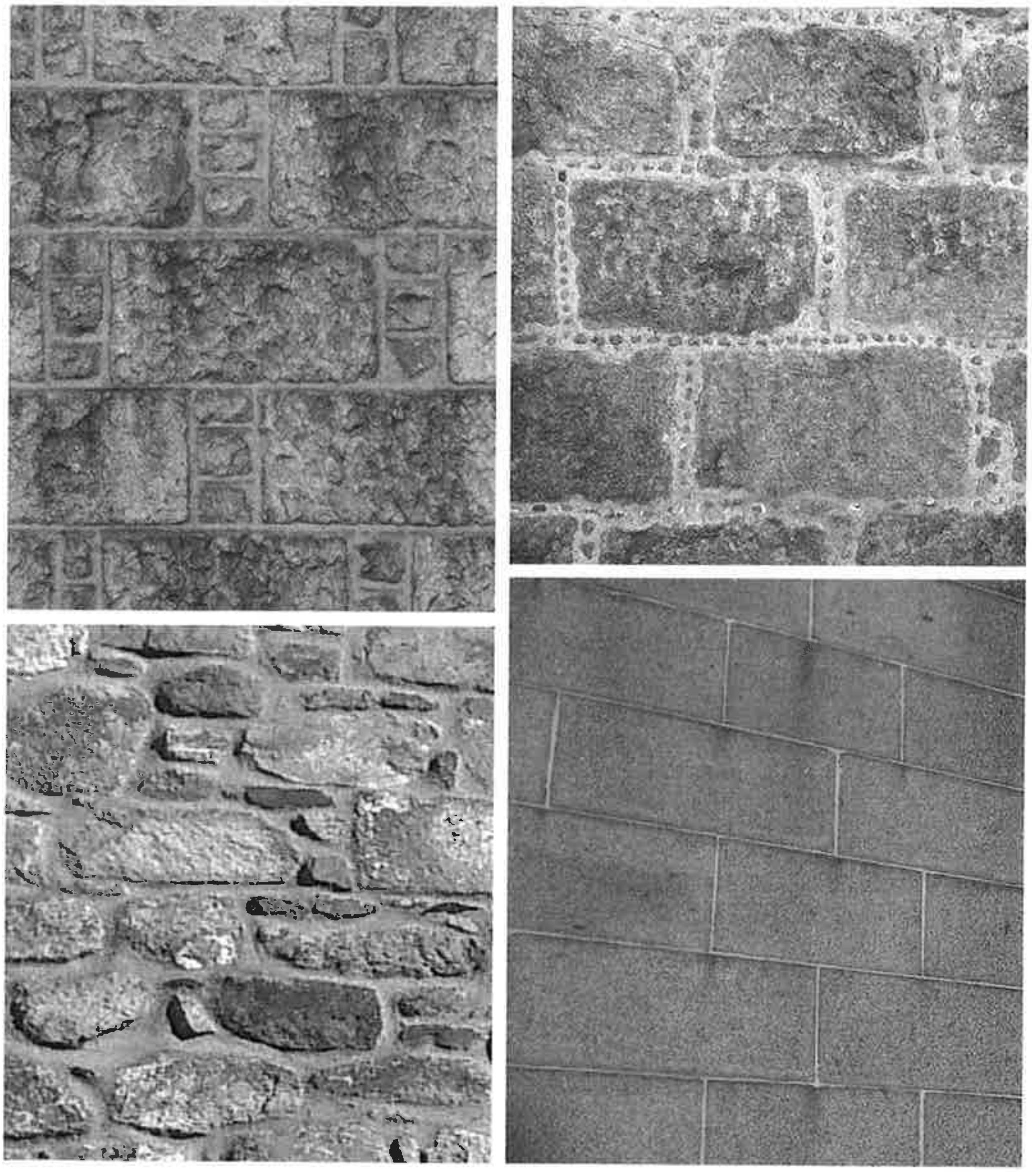

Figure 2: A selection of granite wall external finishes

are assumed to possess lower permeability and flexibility and a better resistance to moisture, frost and salt attack. They are, therefore, usually advised for use with strong masonry in exposed, damp environments.[7]

Lime-based mortars do allow the wall to breathe and this is extremely important in granite walls in particular.

CONCLUSIONS

Before even considering the possibility of insulating a granite masonry wall from inside the building (IWI), it is essential to ensure that the building is structurally sound and has been well maintained. All the critical details of the building junctions — at wall to floor, window, door, roof etc. — should be considered and their condition must be excellent; if not, then remedial action will be necessary.

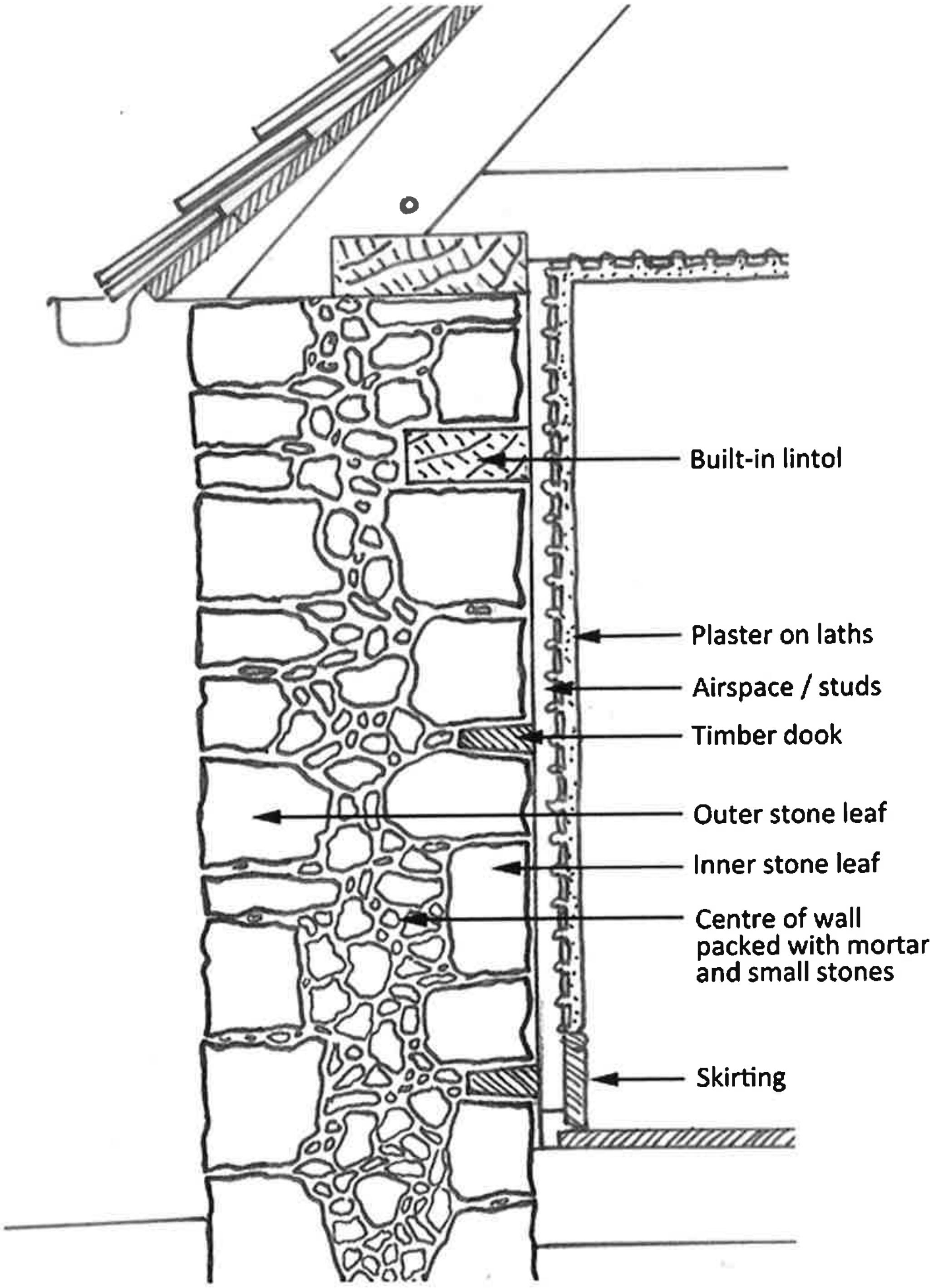

Figure 3: (a) Traditional masonry wall sections

(b) (c)

Figure 3: (Continued) (b) granite wall at window ingoe; (c) partly demolished granite wall

The condition of rainwater goods, wall pointing and seals around openings will each have a significant impact on both the amount of water entering the structural wall, the depth of penetration and the drying cycle.

The cavity within the lath and plaster internal finish is naturally breached as a result of the original construction because of joists built into the outer walls, dooks, which support the vertical strapping, and the debris that collects as a result of broken plaster keys and the like. All of these allow the penetration of moisture from the masonry to the internal finishes, given the appropriate conditions. These are issues that should be regularly considered, in any case, by the building's owner.

If the building has been repointed in OPC mortar then the options for IWI are severely limited. Indeed, there is now a body of evidence to suggest that the extensive tenemental refurbishment programme of the mid 1970s to 1990s has caused more damage to the internal environment and led to early degradation of the structure. Since that time, the knowledge base of built environment professionals has improved as a result of these problems and relatively few examples of repointing in OPC mortars have been found.

The long-term monitoring of the hygrothermal performance of the granite wall and the profiling of the changing nature of the structure might present us with a data set that allows more pertinent consideration of IWI insulation strategies. Various pilot projects using different insulation types have been pursued with sandstone and limestone-based walling, with detailed and long-term monitoring taking place, and in some of these projects insulation has been inserted between the internal face of the stone and the lath and plaster cavity. Smaller scale individual projects, with similar insulation strategies, have been carried out over the years (at least since 1988), but problems have existed with valuation surveyors in terms of recommending such properties for mortgage purposes, as such works seem contrary to normal accepted practice.

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